Development of Spectrophotometric On-Line Monitoring System for Groundwater Near Silo Repository

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1. Introduction

Low- and intermediate-level radioactive wastes (LILW) are currently being stored in silo type repositories in Gyeongju. In order to prevent the release of radionuclide to the environment, a multi-barrier system, including natural geological barrier, and an engineered barrier system (EBS), has been designed. Since radionuclide migration from the repository to the geosphere occurs through the groundwater, monitoring of the groundwater system is necessary to evaluate the performance of disposal system after the closure.

For that purpose, we developed an on-line monitoring system based on the UV-Vis absorption spectrometry coupled with liquid waveguide capillary cell (LWCC) in order to detect iron, cobalt, and nickel ions, which are short half-life radionuclides existing in the groundwater.

2. Experimental

2.1 Performance assessment model

The performance assessment model for LILW repository was developed using the GoldSim (Ver.11) of the Monte Carlo based program. The silo repository and trench type repository, which make up the LILW, were developed in separated sub-modules. Details applied in the model are identical to the previous work [1].

2.2 UV-Vis absorption spectrophotometry

All absorption spectra was measured with the UV-Vis absorption spectrometer (MCS601 UV-NIR-C, Carl Zeiss) coupled with LWCC (LWCC-4100, World Precision Instruments). 2-(5-bromo-2pyridylazo)-5-(N-propyl-N-3-sulfopropylamino)phenol (Br-PAPS) (Sigma-Aldrich) was used as chelating reagent. Solvent degassing unit (AG-32, Gastorr) was applied to remove existing micro-bubbles, which may interfered with the signal.

3. Result and Discussion

Sorption is the main retardation process for the transport of radionuclide from the repository to geosphere and is quantified by the distribution coefficient (K_d). The distribution coefficient is strongly dependent on the geochemical conditions, such as pH, temperature, composition of soils and etc [2].

The annual dose rate was calculated with different distribution coefficient in two scenarios as seen in Fig. 1: normal and abnormal.

In normal scenario, it is hypothesized conservatively that the silo is fully saturated with groundwater and waste drum loses its credibility right after the closure. While, in abnormal scenario, it is hypothesized that the distribution coefficients are considered to be decreased by one thousandth. As represented in Fig. 1, in abnormal scenario, the

annual dose rate becomes dominated by short half-life radionuclides such as ^{55}Fe, ^{60}Co, ^{63}Ni, ^{90}Sr, and ^{137}Cs, unlike the normal scenario.

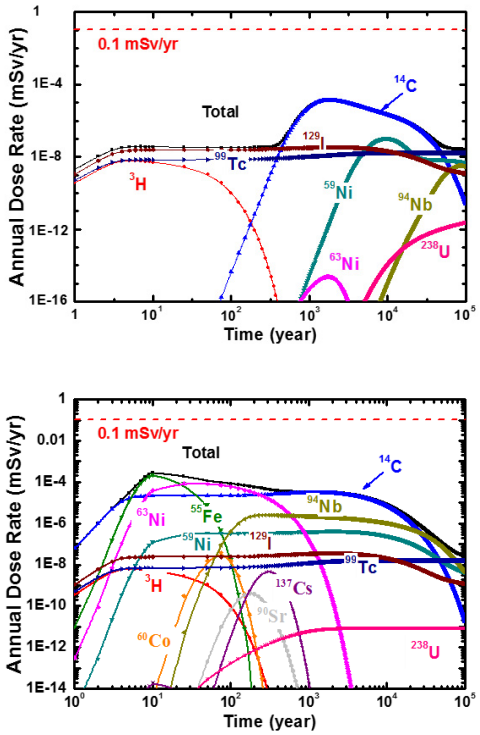

Fig. 1. Annual dose rate (a) normal scenario (top) and (b) abnormal scenario (bottom).

The absorbance of metal Br-PAPS chelate was measured in the metal concentration range from 10^{-9} mol/L to 10^{-8} mol/L, which is equivalent to approximately 0.05 ppb to 0.5 ppb, respectively, as shown in Fig. 2. The analytical absorbance was evaluated at its second maximum position after background subtraction and detection limits for iron, cobalt and nickel were determined using 3 rule as 0.021 ppb, 0.013 ppb, and 0.008 ppb, respectively.

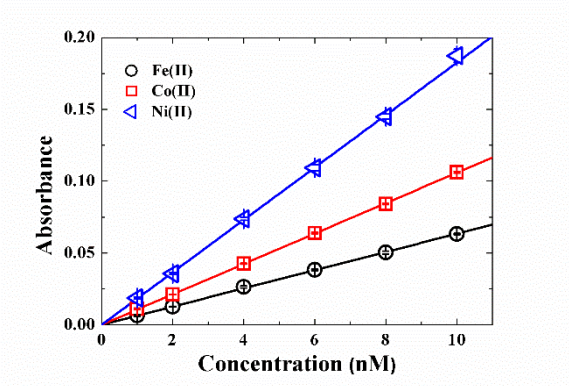

Fig. 2. Calibration curves of metal Br-PAPS chelates ([Fe, Co, Ni] = 10^{-7} M, [Br-PAPS] = 2.5×10^{-7} M, pH=9.0).

4. Conclusions

According to the results from the safe assessment model, short half-life radionuclides become dominated when the distribution coefficient decreases. In this case, the on-line monitoring system developed in this study can be applied to detect such metal ions to evaluate the performance assessment of the repository.

5. Acknowledgement

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